Mobile Networking

Including Application to Aeronautical Internets

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Disclaimer

- The views expressed are those of the author and not necessarily those of NASA or the US Government.

Outline

- Issues
- Mobile Networking Solutions
- Aeronautical Telecommunication Network (ATN)
- IPv4 Operation – Presentations Available
- Additional IPv4 Features
- Security Remarks
- RF Link Technologies
- Mobile-IPv6 Operation
- Networks In Motion (NEMO)
  - Multi-Homing

Aeronautic Networking Issues

- Move to IPv6
  - IPv6 Mobile Networking
- Authentication, Authorization and Accounting
- Bandwidth, Bandwidth, Bandwidth
- Media Access
- Policy
  - Sending of Operations over Entertainment Channels
- $$$
- Deployment Strategy

Mobile Networking Solutions

- Routing Protocols
  - ☺ Route Optimization
  - ☹ Convergence Time
  - ☹ Sharing Infrastructure – who owns the network?
- Mobile-IP
  - ☹ Route Optimization
  - ☺ Convergence Time
  - ☺ Sharing Infrastructure
  - ☺ Security – Relatively Easy to Secure
- Domain Name Servers
  - ☺ Route Optimization
  - ☹ Convergence Time
  - ☹ Reliability

Aeronautical Communication Requirements for ATN

- Interoperability with existing subnetworks
- High availability
- Mobile Communication
- Message prioritization
- Policy based routing
- Security
  - Just now being considered
- Bit Efficiency
- Support for multiple mobile subnetworks
- Mobile platform forms its own Routing domain

Aeronautical Communication Requirements – Questions?

- How much is politics, how much is technical requirements.
  - Policy based routing
    - Is this a political or technical requirement?
    - Policy based routing and QoS are not the same thing.
  - Security – Previously undefined
    - Can Links handle Authentication, Authorization, Accounting and Encryption?
- Bit Efficiency
  - Is this due to limited links?
- Load Sharing of RF links
  - Is this specified, **implied** or not necessary?
  - Current (and perhaps future) implementations of Mobile Networking do not support this.

ATN Non-Requirements

- Sharing Infrastructure
- Multicasting
- Interoperate with non-ATN applications
- Unidirectional Link Routing
- Use of Commodity products and protocols
- Cost Effective
- Flexible
- Adaptable
- Evolvable

ATN Solutions for Mobility

- Uses Inter-Domain Routing Protocol (IDRP) for routing
- Implements distributed IDRP directory using Boundary Intermediate Systems (BISs)
- Two level directory
  - ATN Island concept consisting of backbone BISs
  - Home BISs concept
- Scalability obtained by the two level structure
- Resilience is provided by the distributed approach

ATN

- ATN Routing uses the IDRP Routing Protocol
  - IDRP supports policy-based based routing which allows administrations to autonomously control use of their network
  - IDRP supports mobility by permitting aggregate routes to be selectively propagated through the network

Securing Mobile and Wireless Networks

Some ways may be “better” than others!

Constraints / Tools

- Policy
- Architecture
- Protocols

AAA

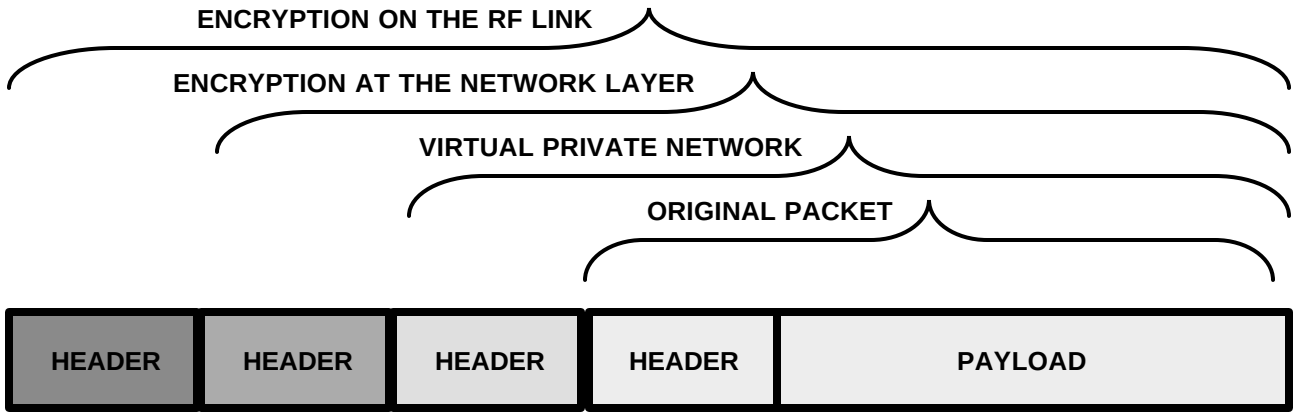
- Authentication
  - Who are you/device really?
- Authorization
  - What are you/device allowed to do?
  - Did you pay your bill?
- Accounting
  - How much services are you using this time?

Network Security via Encryption

- Security ↑ Bandwidth Utilization ↓
- Security ↑ Performance ↓
- Tunnels Tunnels Tunnels and more Tunnels
- Performance ↓ Security ↓

  ⇒ User turns OFF Security to make system usable!
- Thus, we need more bandwidth to ensure security.

ATN started here.



RF Link Technologies

RF Technologies – partial list

- Globalstar (L-Band)
  - Globalstar MCM-8 (Client/Server), 56 kbps BOD
  - Seatel MCM-3 (Client/Server), 21 kbps
  - Qualcomm MDSS-16, 112 kbps
- Boeing Connex (Ku-Band), 2+ Mbps in/100+ kbps out
- INMARSAT Swift 64, 64 kbps
- General Packet Radio Service (GPRS), 56 kbps
- 802.11, 5+ Mbps simplex
- VHF (VDL-x)

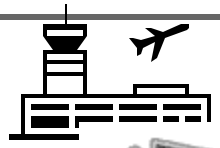
VHF Data Link (VDL)

- VDL-1: 600 bps Carrier Sense Multiple Access (CSMA)
- VDL-2: D8PSK, 32.5 kbps, CSMA (Deployment 5+ years)
- VDL-3: D8PSK, 4 channels at 8 kbps TDMA (Deployment 10+ years)
- VDL-4: D8PSK, 4 channels at 8 kbps, Self Synchronizing

Place Appropriate Picture Here

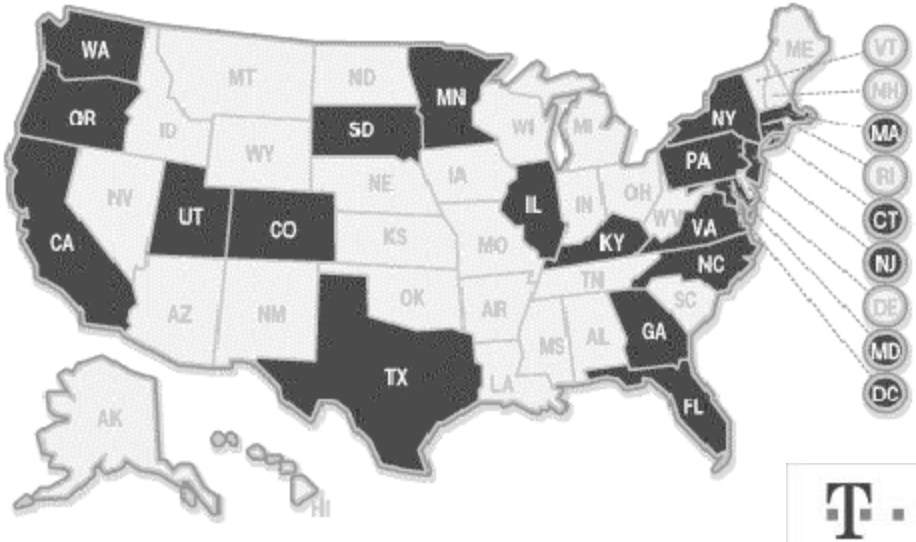
Hot Spot Partners – 2500+ sites (4/1/03)

BORDERS®



T-Mobile

UNITED



STARBUCKS COFFEE

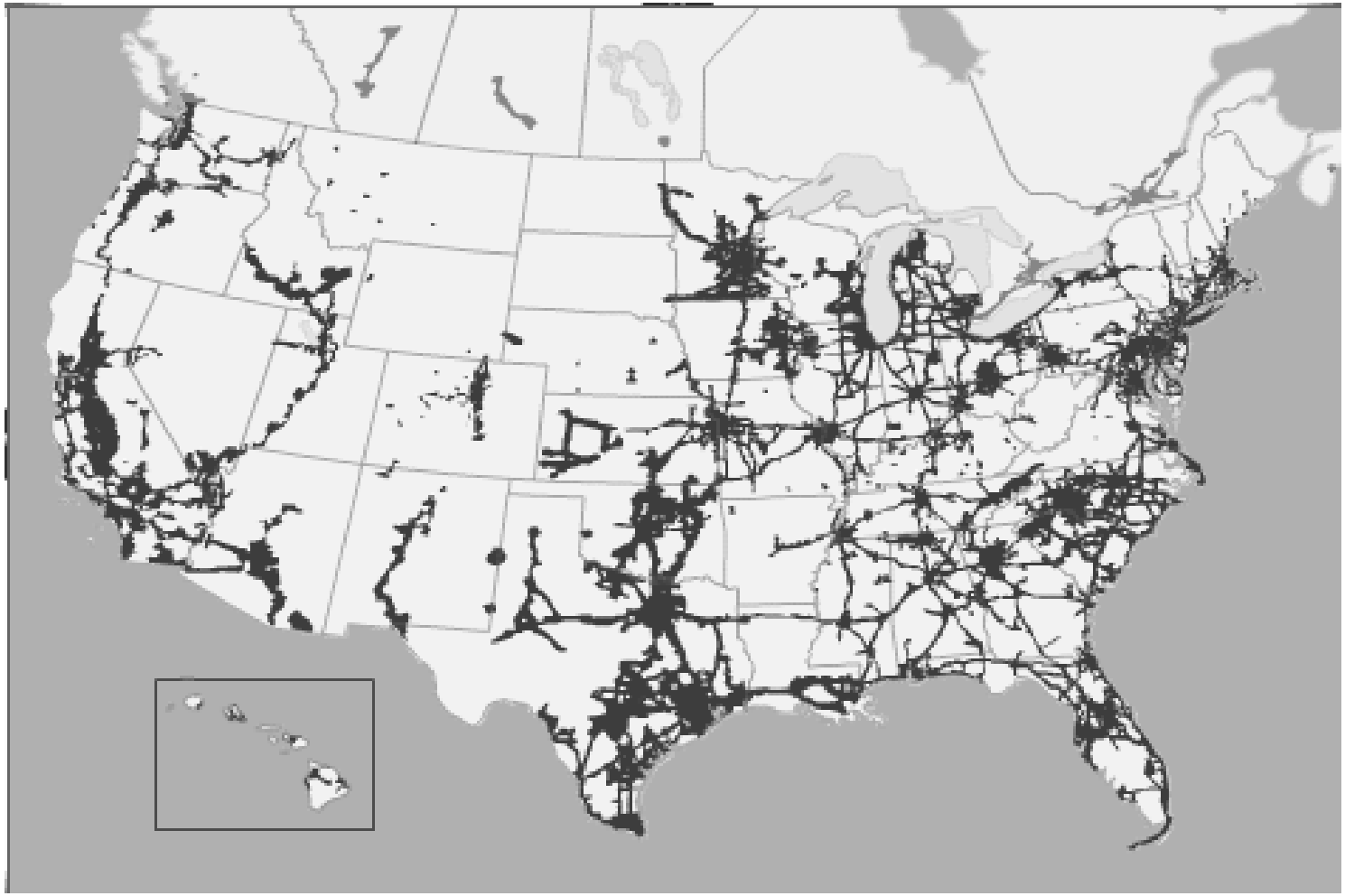
T-Mobile HotSpot

Wireless broadband Internet access for your laptop or PDA.

AmericanAirlines®

Delta

T-Mobile GPRS coverage (56 kbps)



IPv6 Mobile-IP

Mobile-IPv6 (Mobile Hosts)

- No "foreign agent“ routers
- Route optimization is a fundamental part of the protocol
- Mobile IPv6 route optimization can operate securely even without pre-arranged security associations
- Route optimization coexists efficiently with routers that perform "ingress filtering"
- The movement detection mechanism in Mobile IPv6 provides bidirectional confirmation of a mobile node's ability to communicate with its default router in its current location
- Most packets sent to a mobile node while away from home in Mobile IPv6 are sent using an IPv6 routing header rather than IP encapsulation

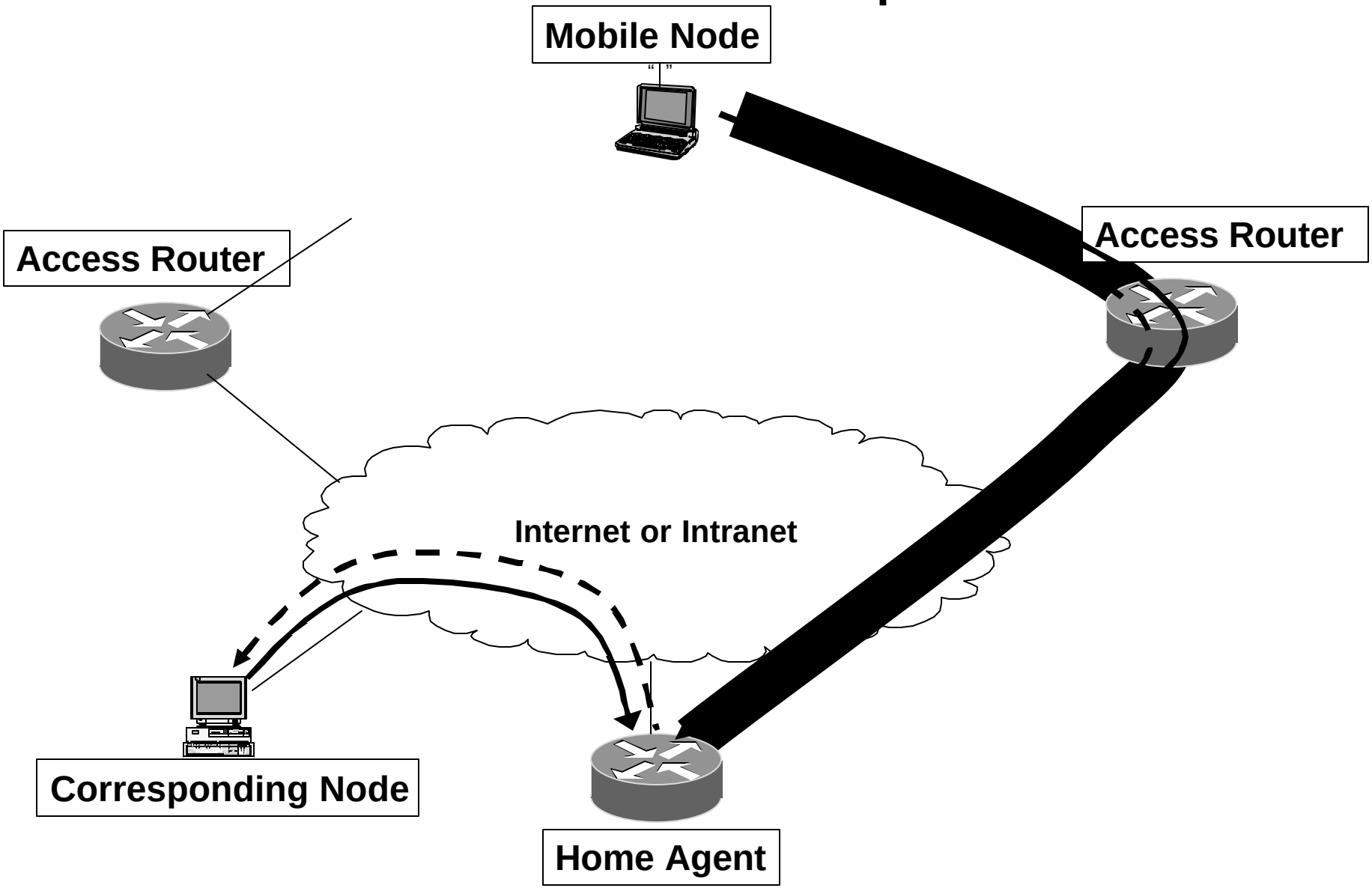
Mobility Message Types

- Binding Refresh Request Message
- Home Test Init Message
- Care-of Test Init Message
- Home Test Message
- Care-of Test Message
- Binding Update Message
- Binding Acknowledgement Message
- Binding Error Message

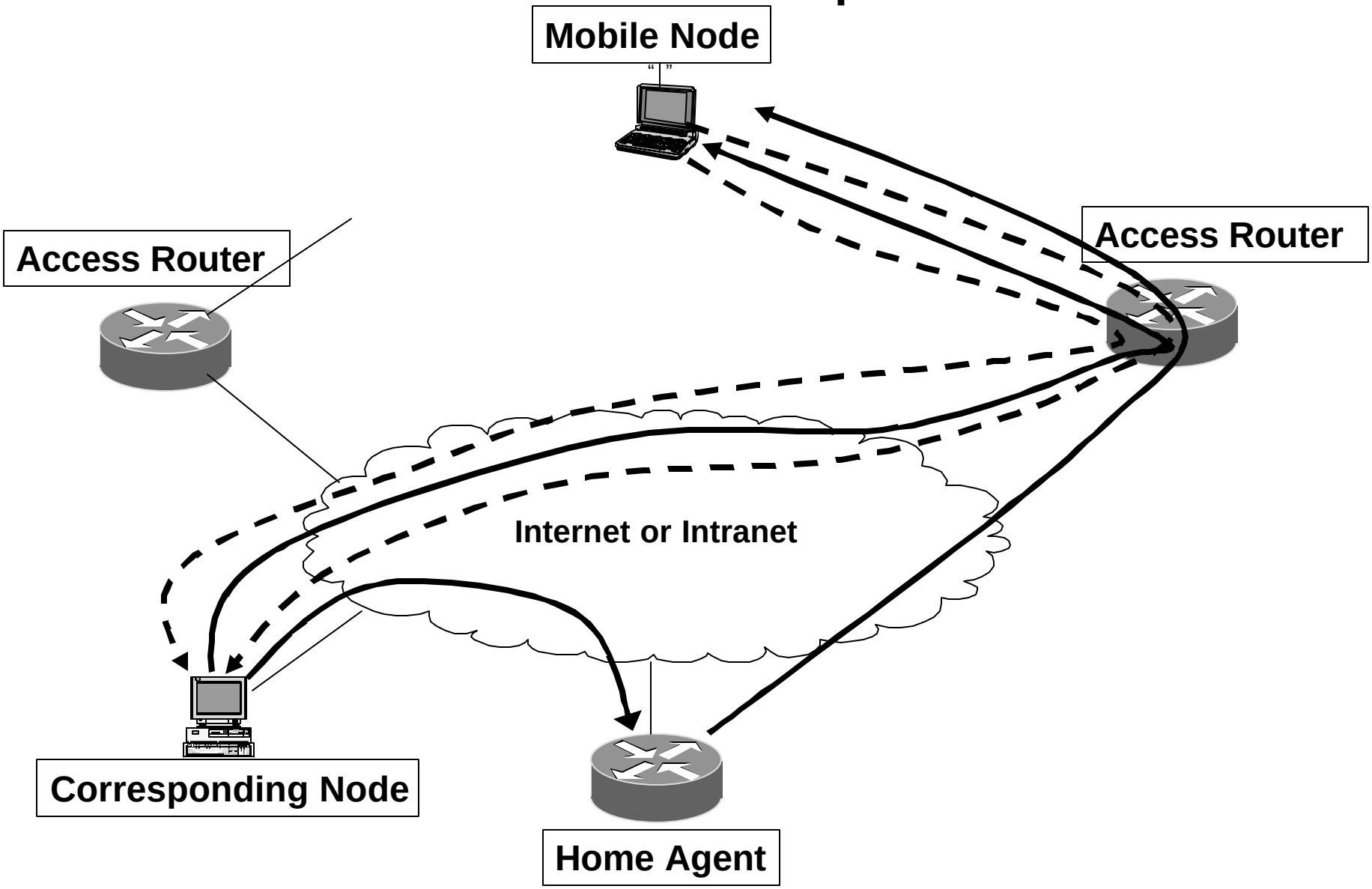
Mobile-IPv6

- Modes for communications between the mobile node and a correspondent node
  - Bidirectional tunneling
    - Does not require Mobile IPv6 support from the correspondent node
  - “Route Optimization“
    - Requires the mobile node to register its current binding at the correspondent node.
    - Packets from the correspondent node can be routed directly to the care-of address of the mobile node

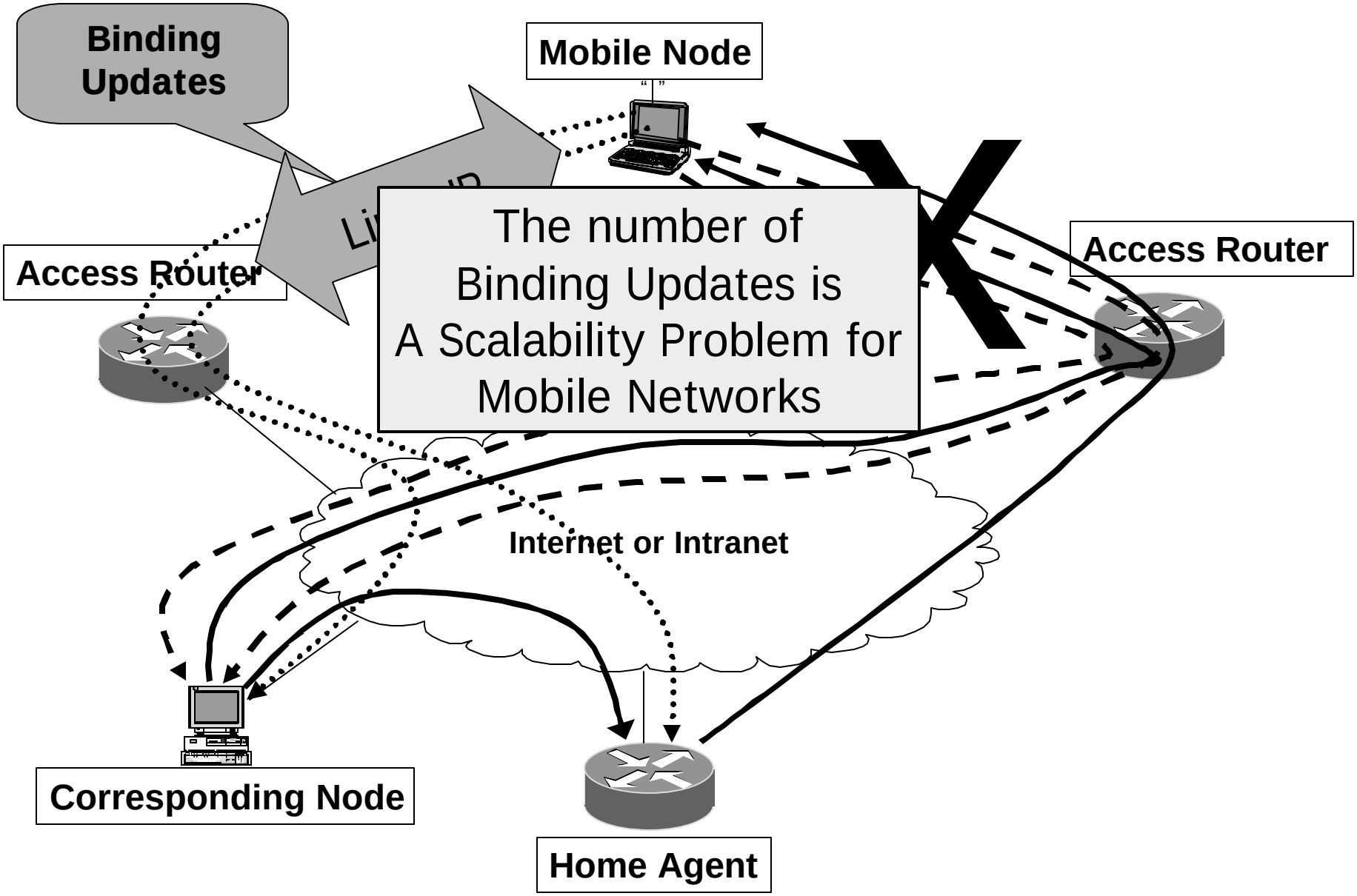
Mobile-IPv6 using Reverse Tunneling
CN is Not Mobile-IPv6 Capable



Mobile-IPv6 using Route Optimization
CN IS Mobile-IPv6 Capable



Mobile-IPv6 Binding Updates



Mobile IPv6 Security

- Binding Updates use IPsec extension headers, or by the use of the Binding Authorization Data option
- Prefix discovery is protected through the use of IPsec extension headers
- Mechanisms related to transporting payload packets - such as the Home Address destination option and type 2 routing header have been specified in a manner which restricts their use in attacks

NEMO

NEtworks in MOtion

http://www.ietf.org/html.charters/nemo-charter.html

http://www.nal.motlabs.com/nemo/

Networks In Motion (NEMO)

- Working Group established in IETF in December 2002
- Concerned with managing the mobility of an entire network, which changes, as a unit, its point of attachment to the Internet and thus its reachability in the topology.

Goals

- Standardizing some basic support mechanisms based on the bidirectional tunneling approach
- Study the possible approaches and issues with providing more optimal routing

Milestones

- MAR 03 Submit terminology and requirements documents (for Basic support).
- MAY 03 Submit Threat analysis and security requirements for NEMO.
- AUG 03 Submit solution for basic support
- NOV 03 Submit MIB for Basic support
- MAR 04 Submit the analysis of the solution space for route optimization
- JUN 04 Shut down or recharter the WG to solve the route optimization

Arbitrary Configurations

- Simplest case: a mobile network contains just a mobile router and a host.
- Most complicated case: a mobile network is multi-homed and is itself a multi-level aggregation of mobile networks with collectively thousands of mobile routers and hosts.

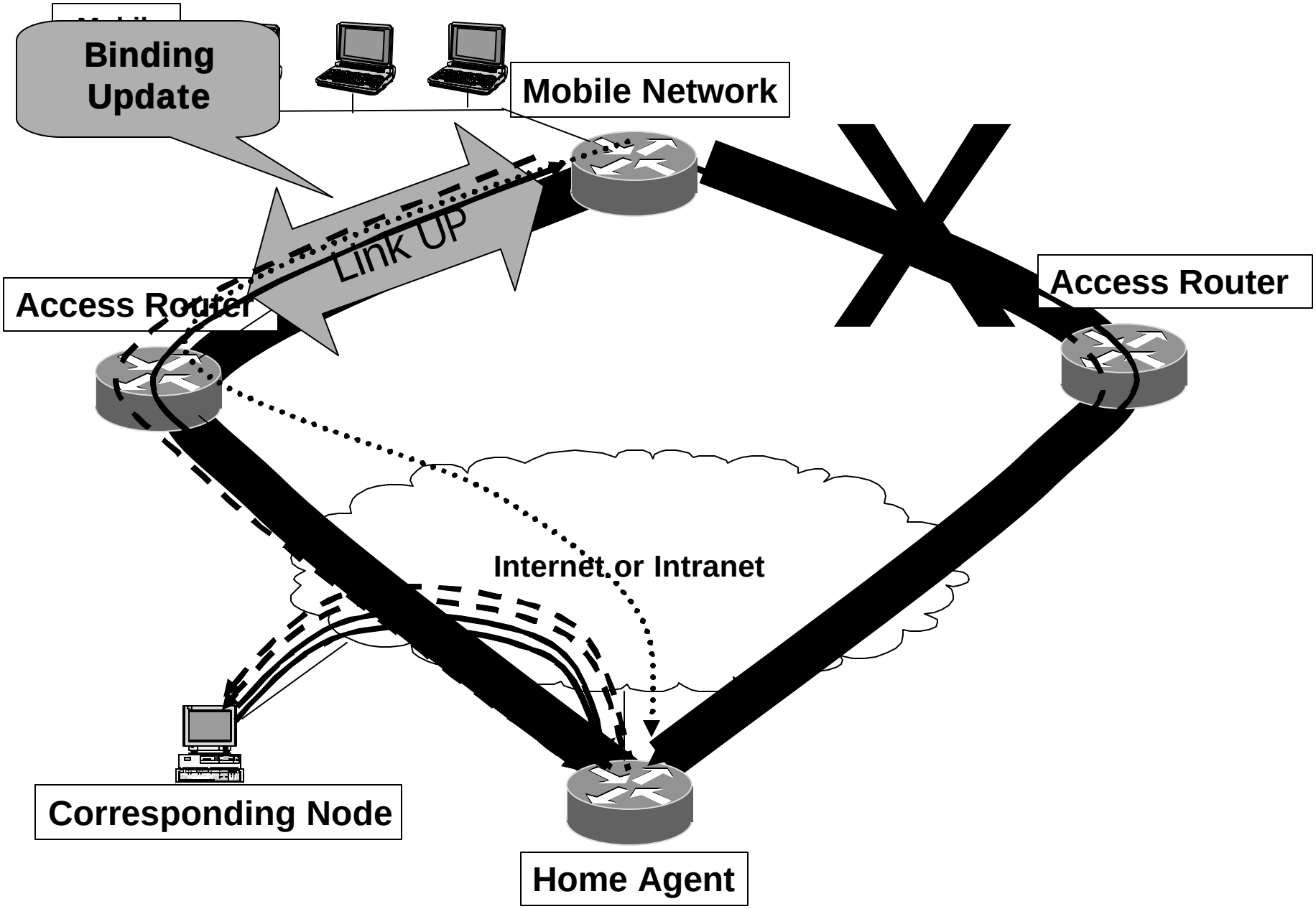
Partial List of Basic Requirements draft-ietf-nemo-requirements-01.txt

- The basic solution MUST use bi-directional tunnels
- MNNs MUST be reachable at a permanent IP address and name.
- MUST maintain continuous sessions (both unicast and multicast) between MNNs and arbitrary CNs after IP handover of (one of) the MR.
- The solution MUST not require modifications to any node other than MRs and HAs.
- The solution MUST support fixed nodes, mobile hosts and mobile routers in the mobile network.
- The solution MUST not prevent the proper operation of Mobile IPv6 (i.e. the solution MUST support MIPv6-enabled MNNs and MUST also allow MNNs to receive and process Binding Updates from arbitrary Mobile Nodes.)
- The solution MUST treat all the potential configurations the same way (whatever the number of subnets, MNNs, nested levels of MRs, egress interfaces, …)
- The solution MUST support mobile networks attaching to other mobile networks (nested mobile networks).

Not Yet required

- Route Optimization
- Load Sharing
- Policy Based Routing
- Multiple Home Agents from different Service Providers
  - Security Issues
  - Desirable for some applications (i.e. air traffic control, airline maintenance, entertainment)

Basic Mobile Network Support for IPv6



Multi-Homing

Multi-Homing

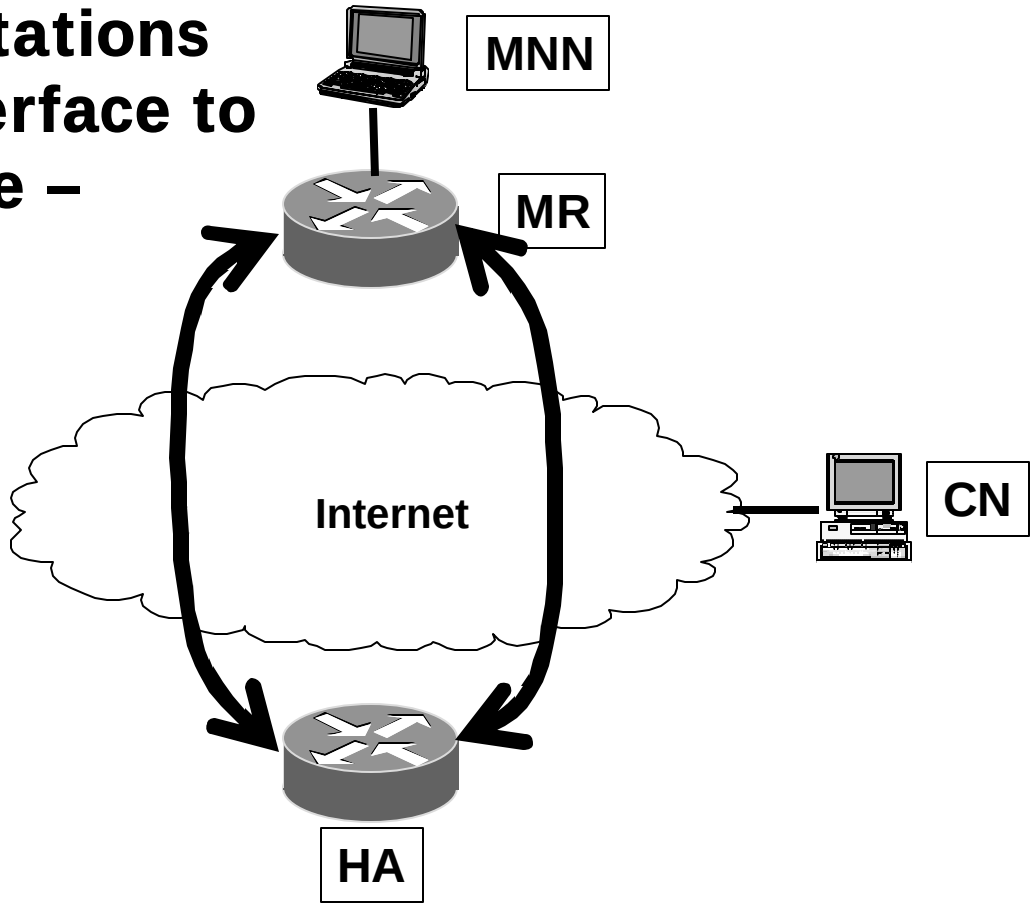
- Issues
  - Load Sharing
  - Policy-Base routing
    - Setting policy over dynamic tunnels
  - Multiple ISPs

Topologies Being Discussed

- (0,0,0): single MR, single HA, single prefix
- (0,0,1): single MR, single HA, multiple prefices
- (0,1,0): single MR, multiple HAs, single prefix
- (0,1,1): single MR, multiple HAs, multiple prefices
- (1,0,0): multiple MRs, single HA, single prefix
- (1,0,1): multiple MRs, single HA, multiple prefices
- (1,1,0): multiple MRs, multiple HAs, single prefix
- (1,1,1): multiple MRs, multiple HAs, multiple prefices

Single MR, Single HA, Single Prefix (Example: Two Interfaces)

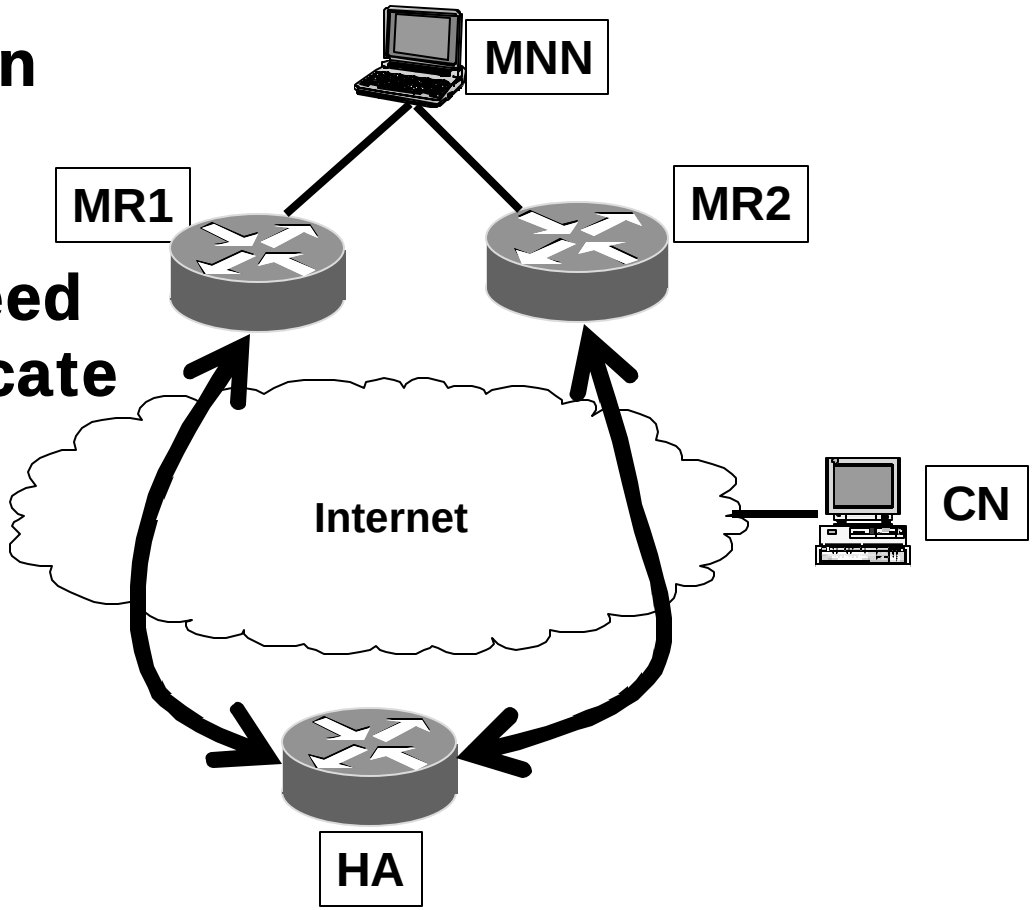
Current Implementations Allow only one interface to Be used at any time – No load sharing.



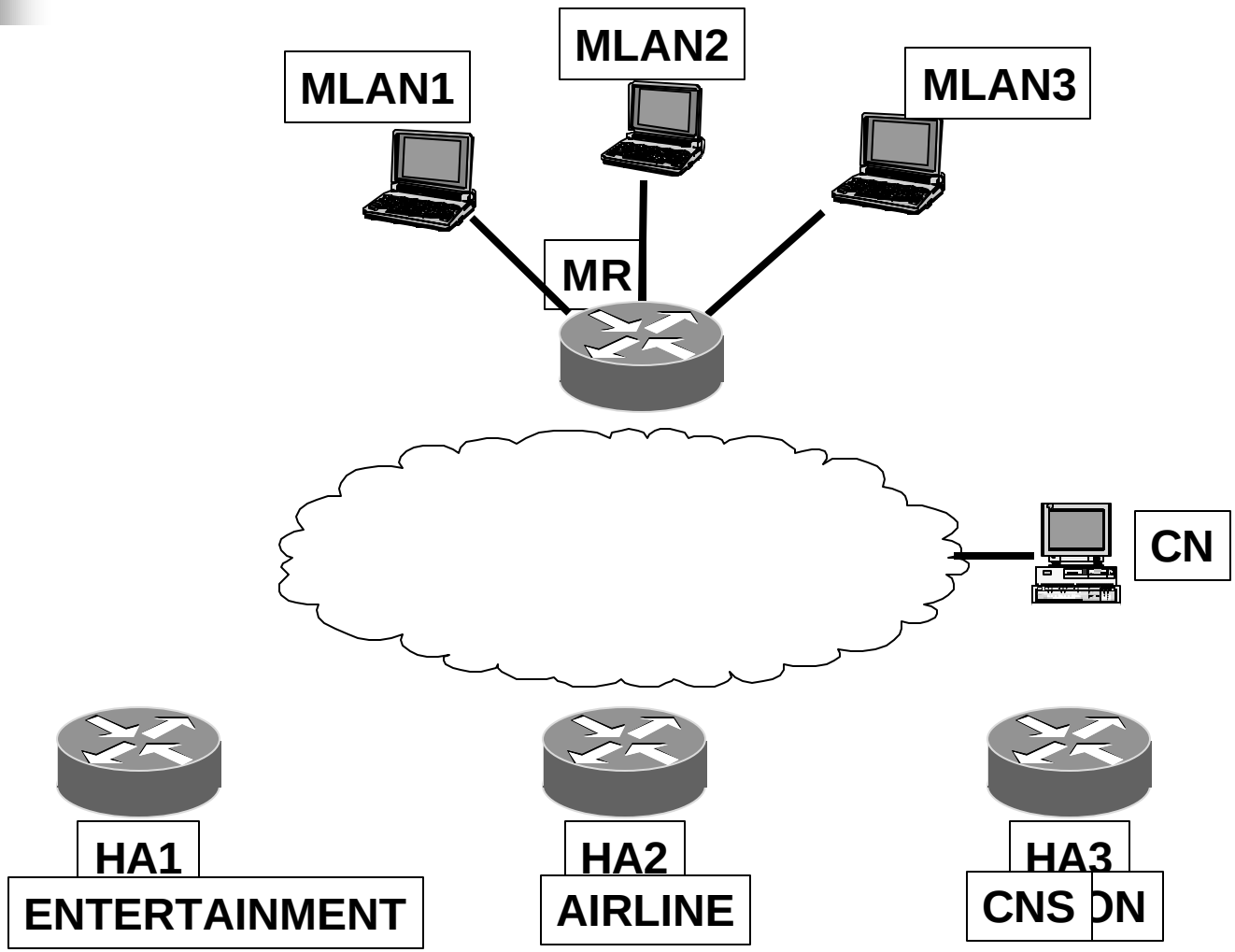
Multiple MRs, Single HA, Single Prefix (Example: Single Interface per MR)

Could Happen Accidentally

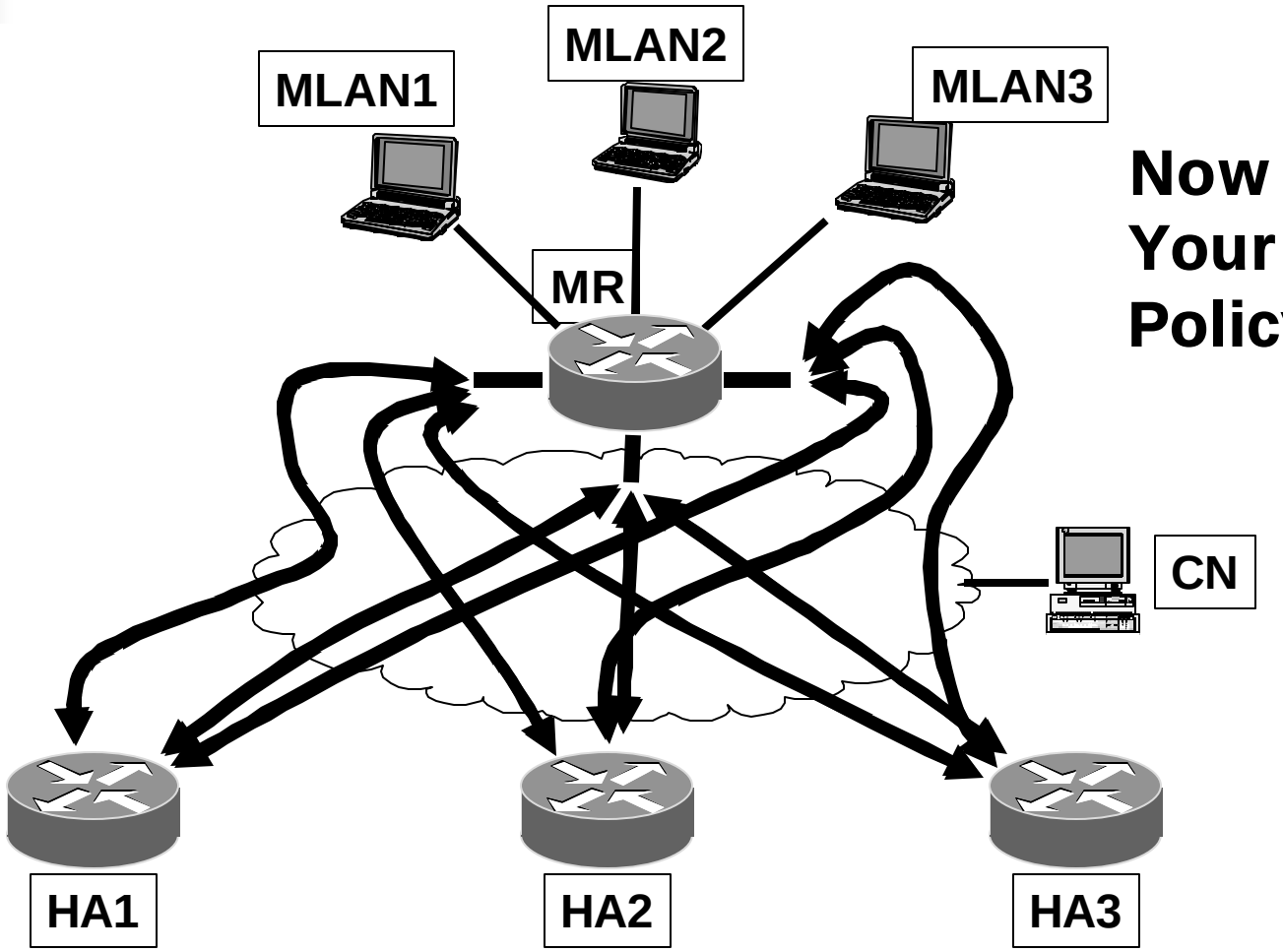
Does MR1 Need To Communicate With MR2?



Single MR, Multiple HAs, Multiple Prefixes (Example: Multiple ISPs per MR)



Single MR, Multiple HAs, Multiple Prefixes (Example: Multiple Interfaces and ISPs per MR)



Now what is Your route Policy?

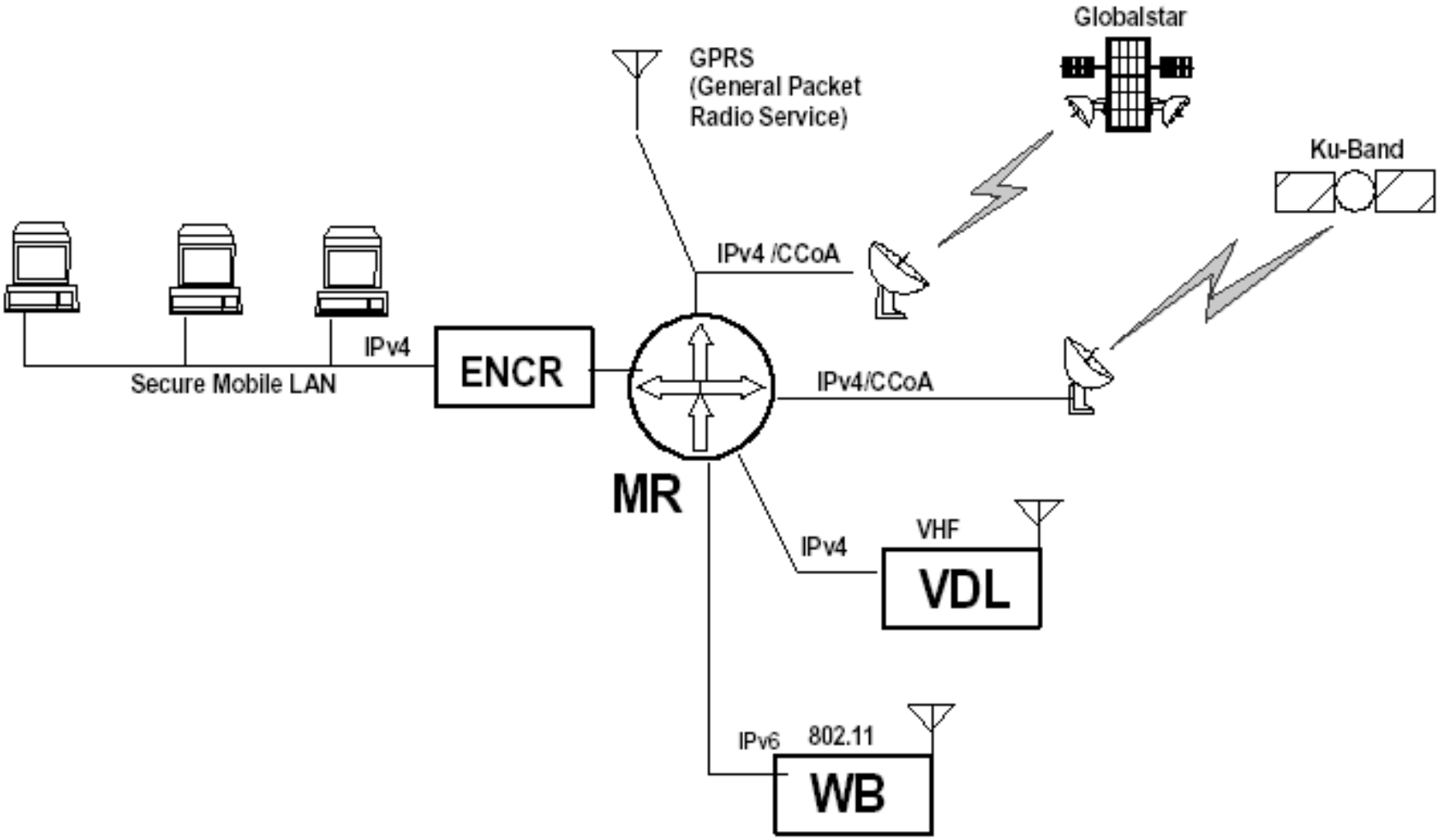
NEMO Experiments

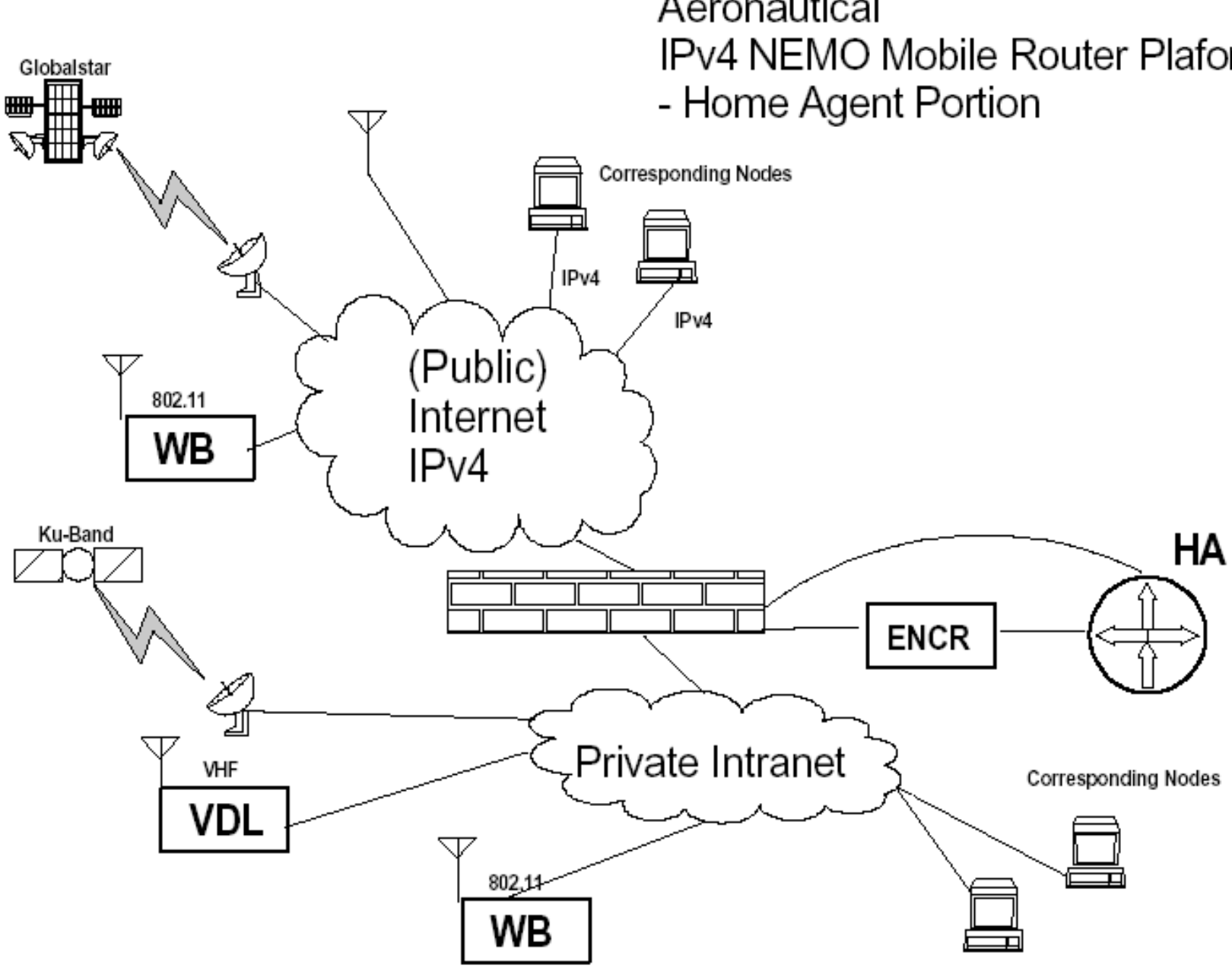
IPv4

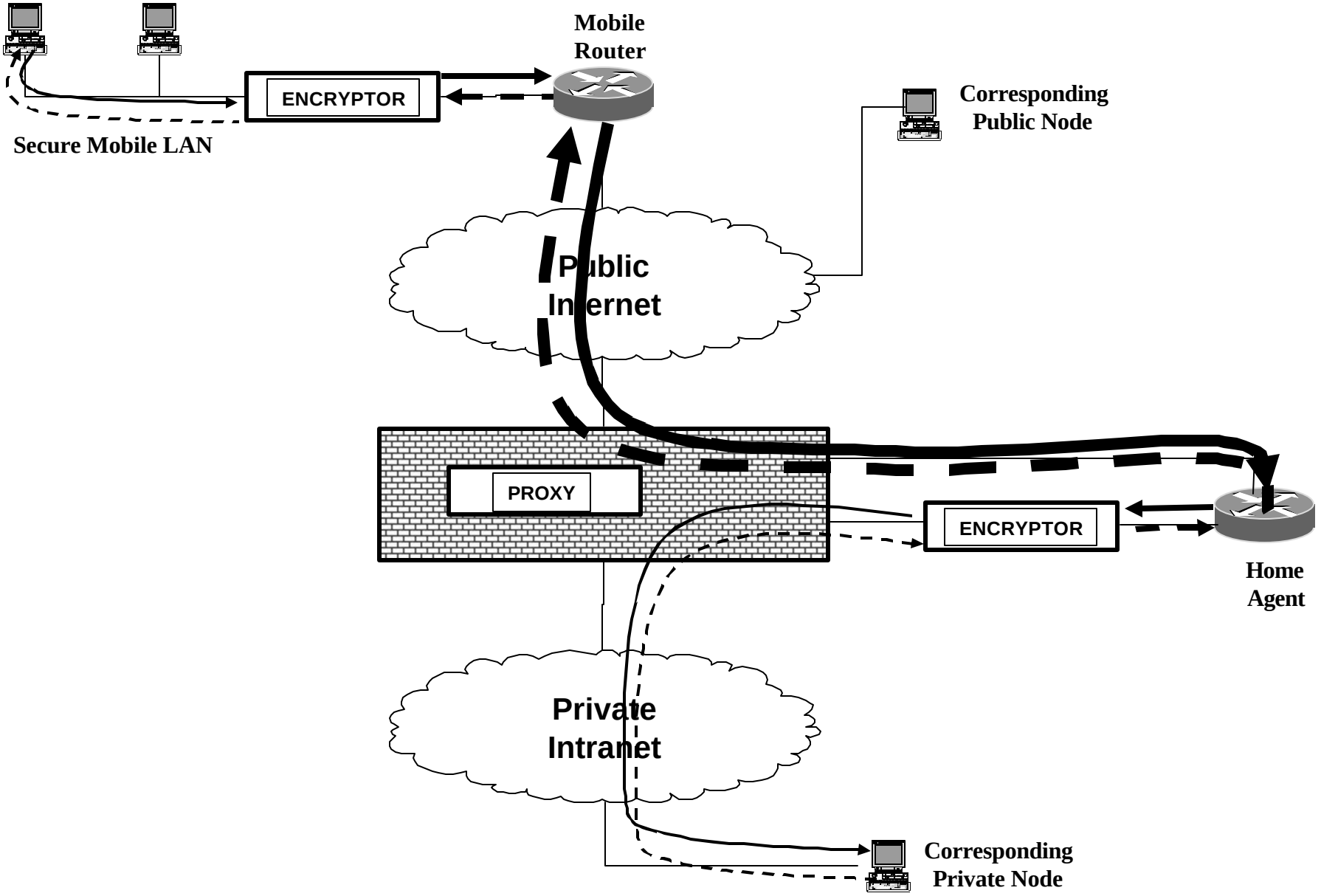
&

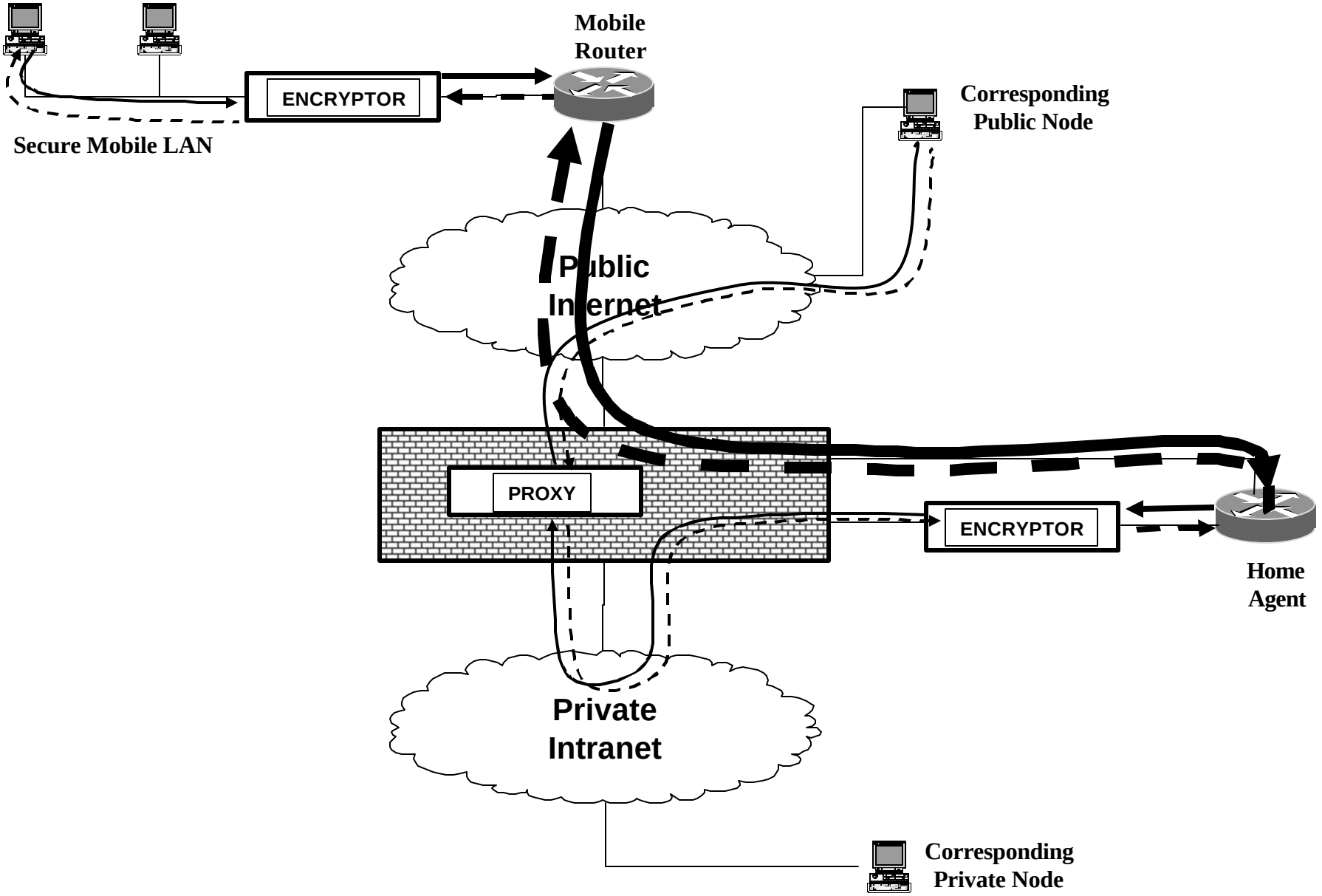
IPv6

Aeronautical
IPv4 NEMO Mobile Router Plaform
- Mobile Router Portion




Aeronautical
IPv4 NEMO Mobile Router Plaform
- Home Agent Portion
Globalstar
Corresponding Nodes
IPv4
IPv4
802.11
WB
(Public)
Internet
IPv4
Ku-Band
HA
ENCR
Private Intranet
VHF
VDL
Corresponding Nodes
802.11
WB


Mobile
Router
ENCRYPTOR
Secure Mobile LAN
Corresponding
Public Node
Public
Internet
PROXY
ENCRYPTOR
Home
Agent
Private
Intranet
Corresponding
Private Node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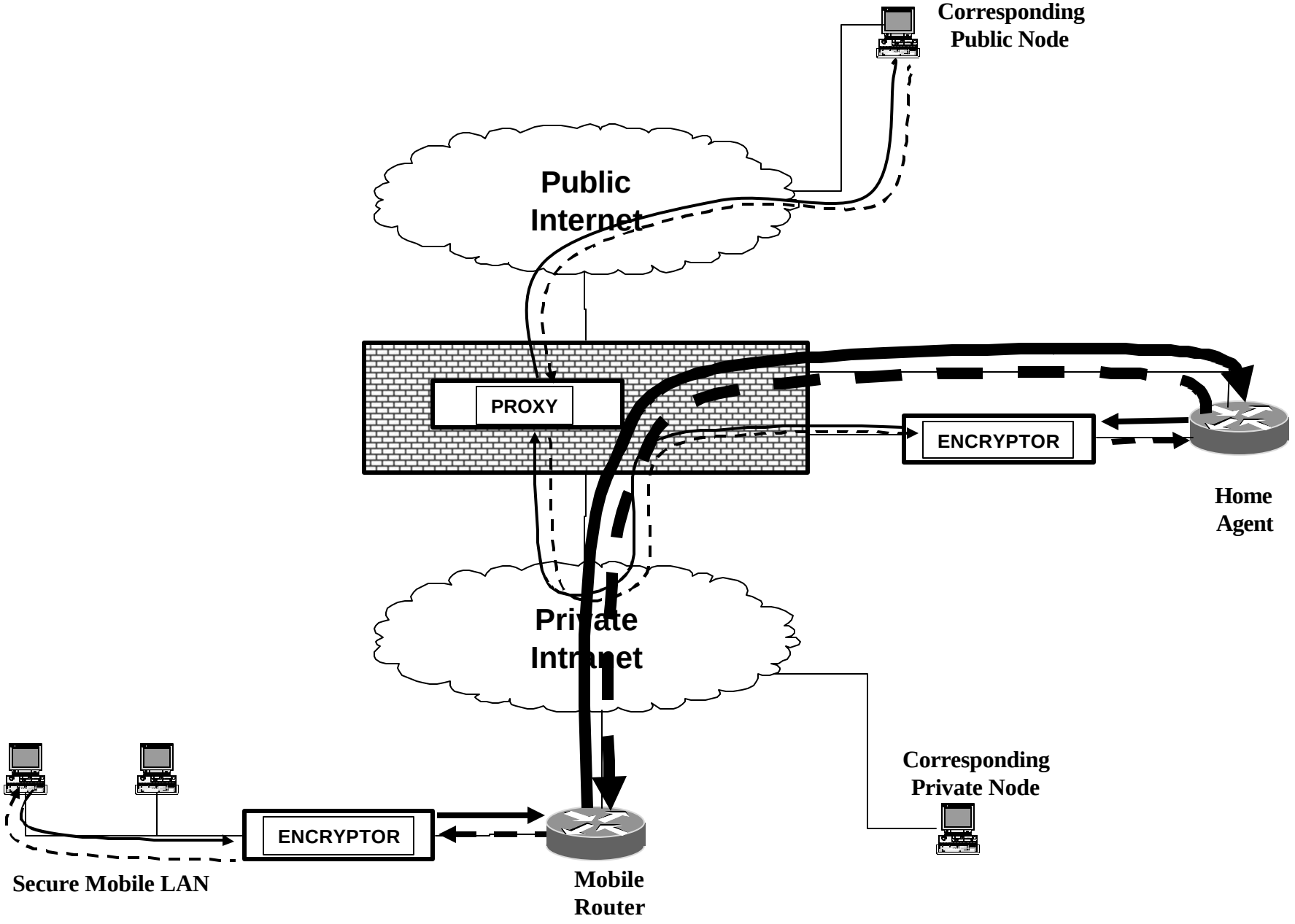
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Public
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Private
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Private Node
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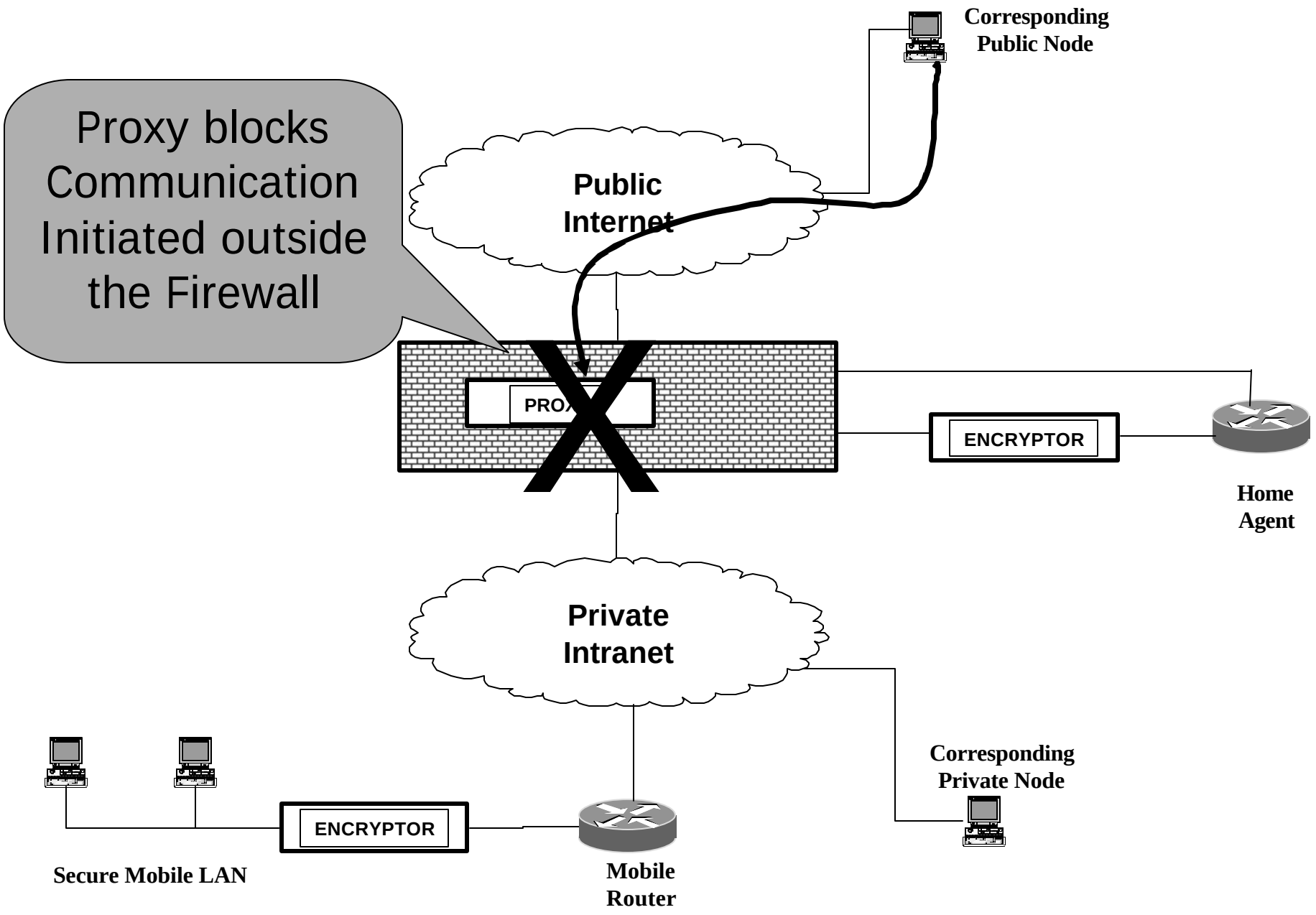
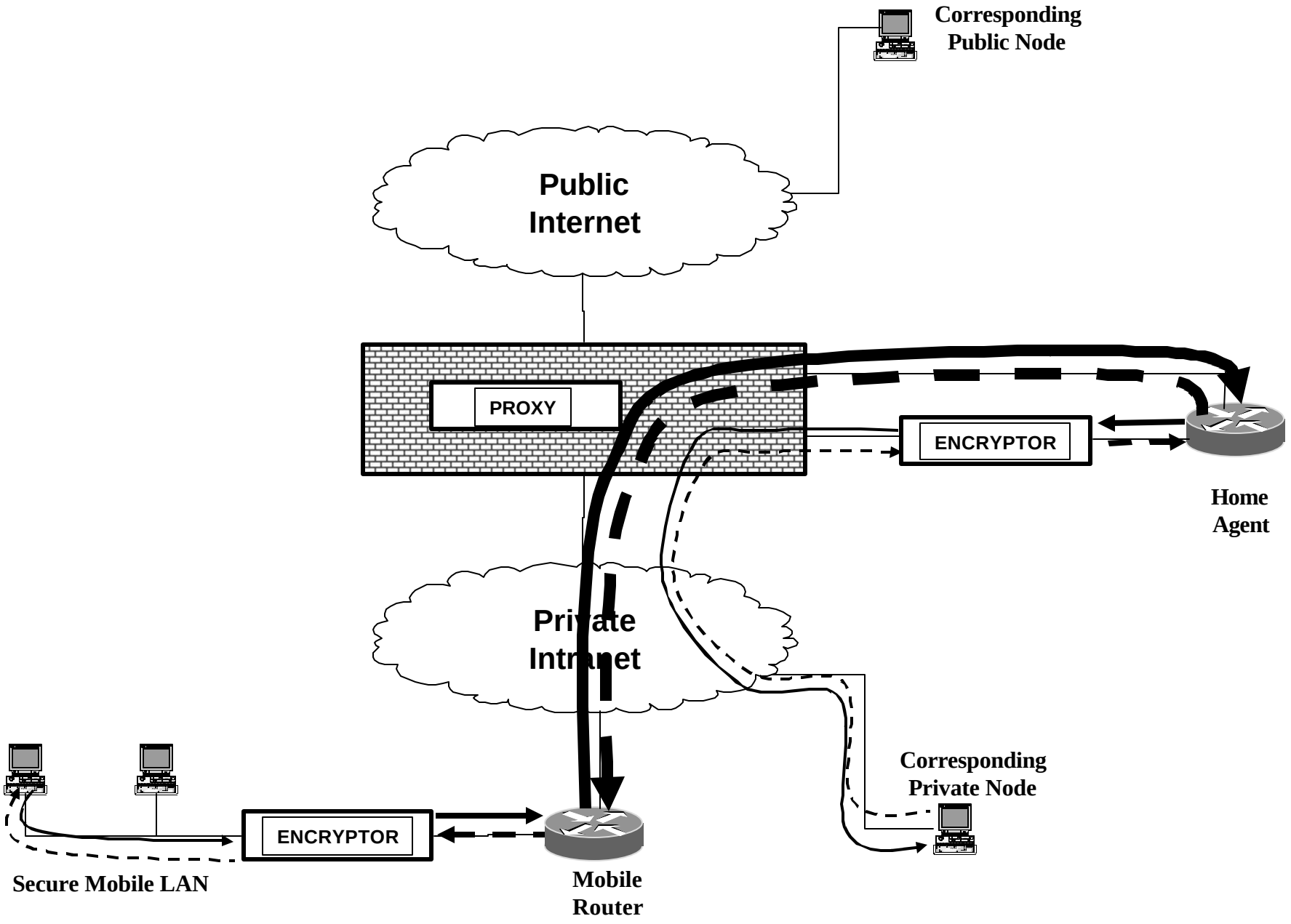
Mobile
Router


Corresponding
Public Node
Proxy blocks
Communication
Initiated outside
the Firewall
Public
Internet
PROX
ENCRYPTOR
Home
Agent
Private
Intranet
Corresponding
Private Node
ENCRYPTOR
Secure Mobile LAN
Mobile
Router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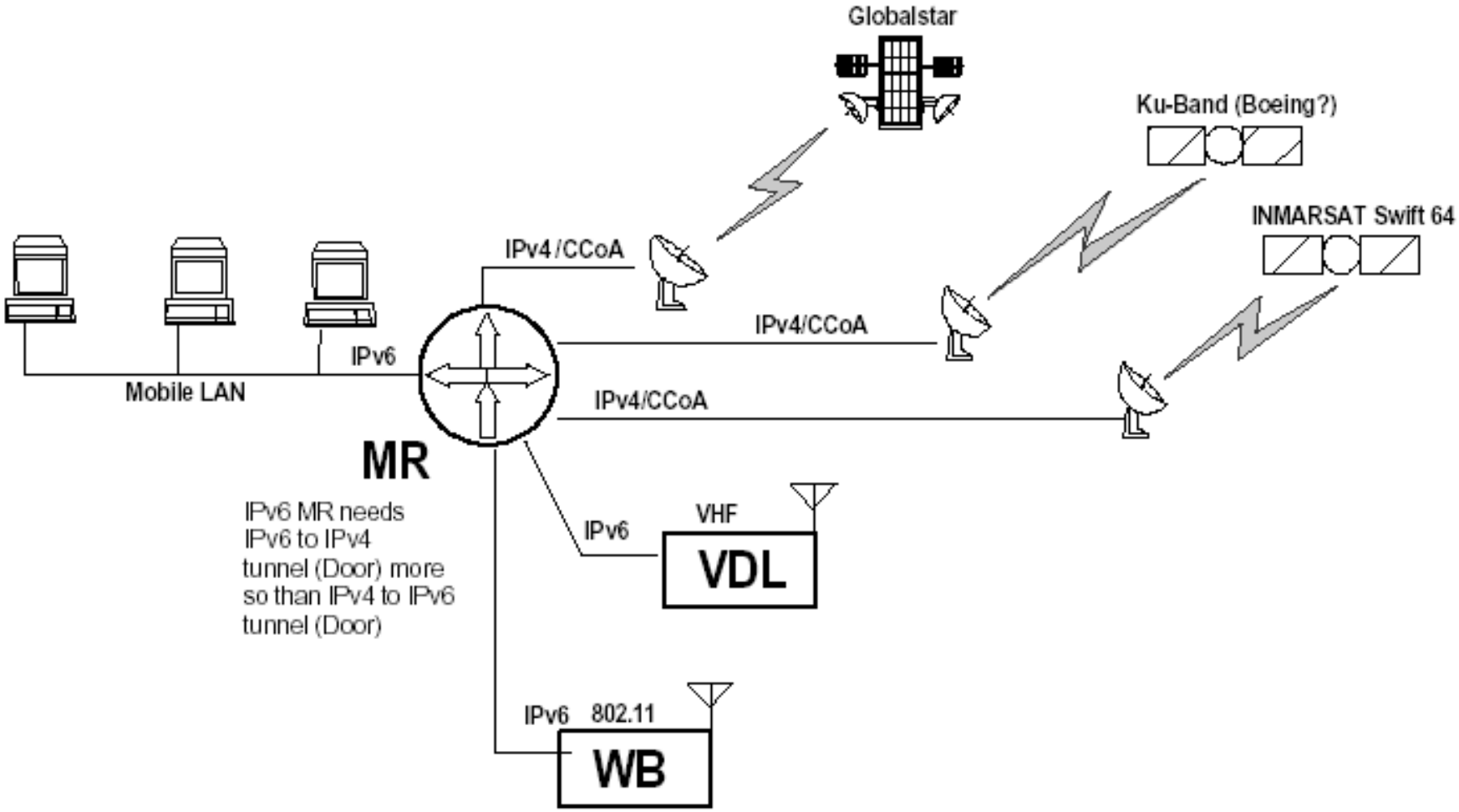
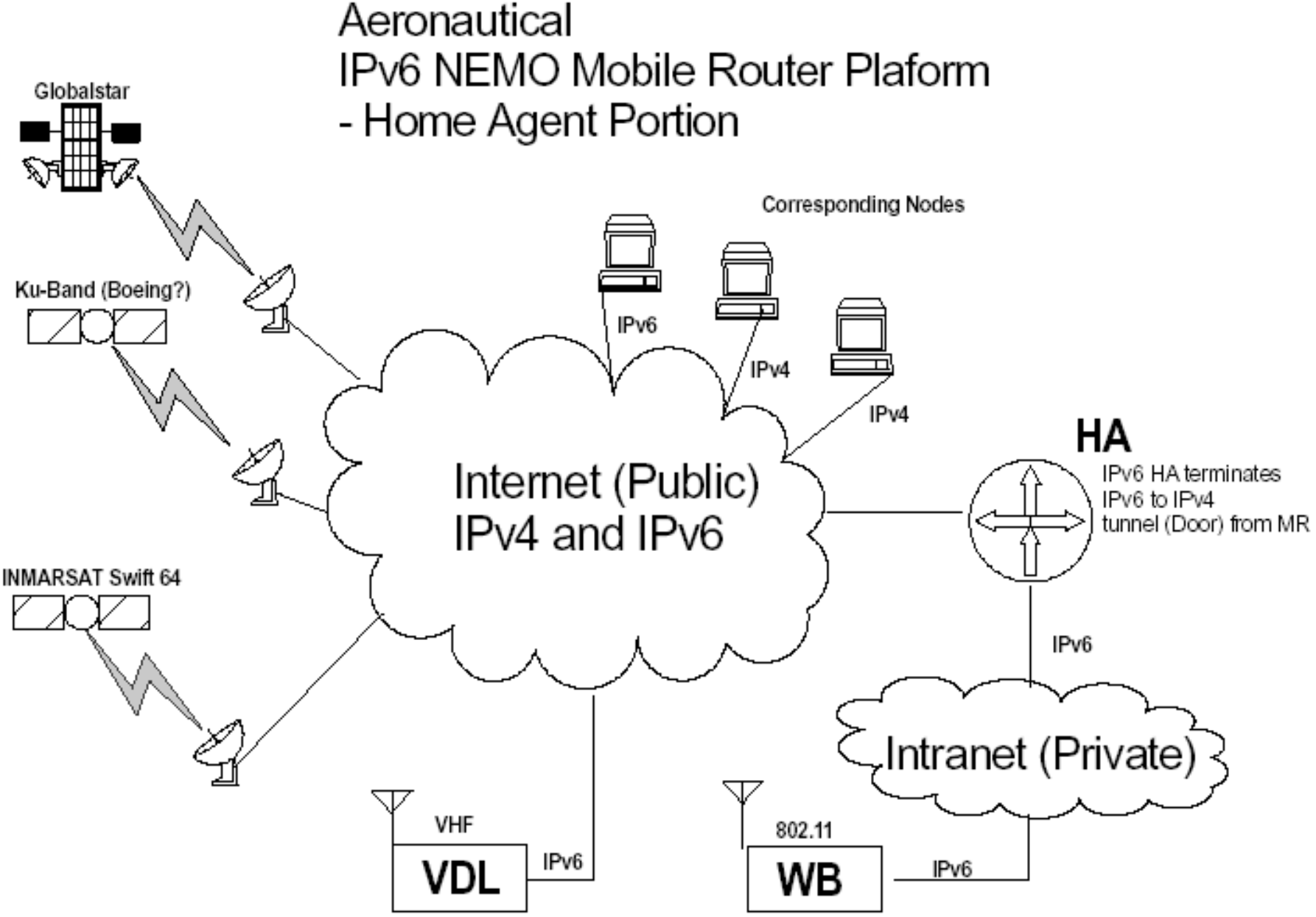
Aeronautical
IPv6 NEMO Mobile Router Plaform
- Mobile Router Portion




Aeronautical
IPv6 NEMO Mobile Router Plaform
- Home Agent Portion
Globalstar
Ku-Band (Boeing?)
INMARSAT Swift 64
Corresponding Nodes
IPv6
IPv4
IPv4
Internet (Public)
IPv4 and IPv6
HA
IPv6 HA terminates
IPv6 to IPv4
tunnel (Door) from MR
IPv6
Intranet (Private)
VHF
VDL
IPv6
802.11
WB
IPv6

Additional Possibilities

- Joint work with Eurocontrol
- Wireless Cabin work being performed by European Consortium using IPv6

Papers and Presentations

http://roland.grc.nasa.gov/~ivancic/papers_presentations/papers.html

or

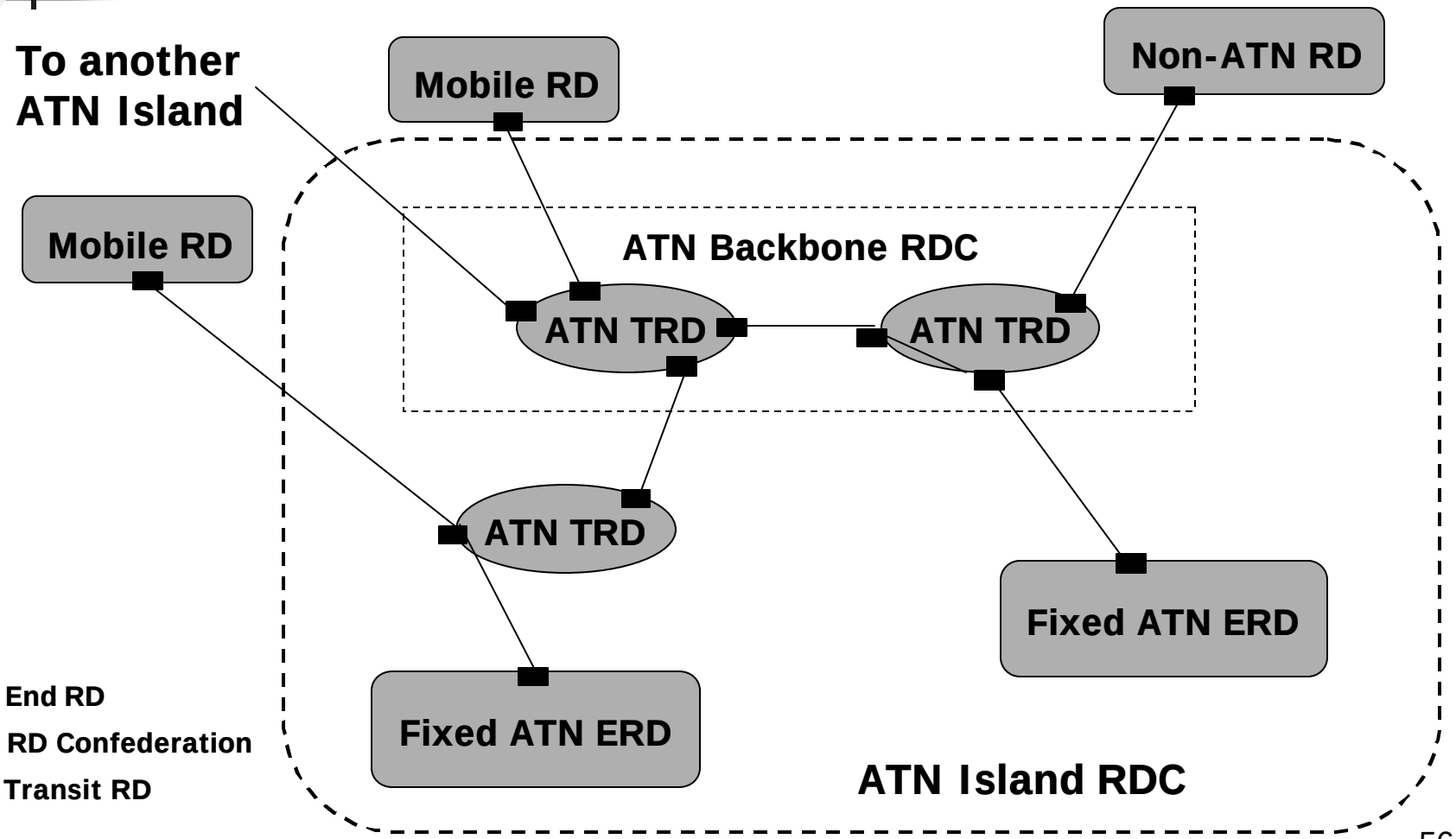
http://roland.grc.nasa.gov/~ivancic/

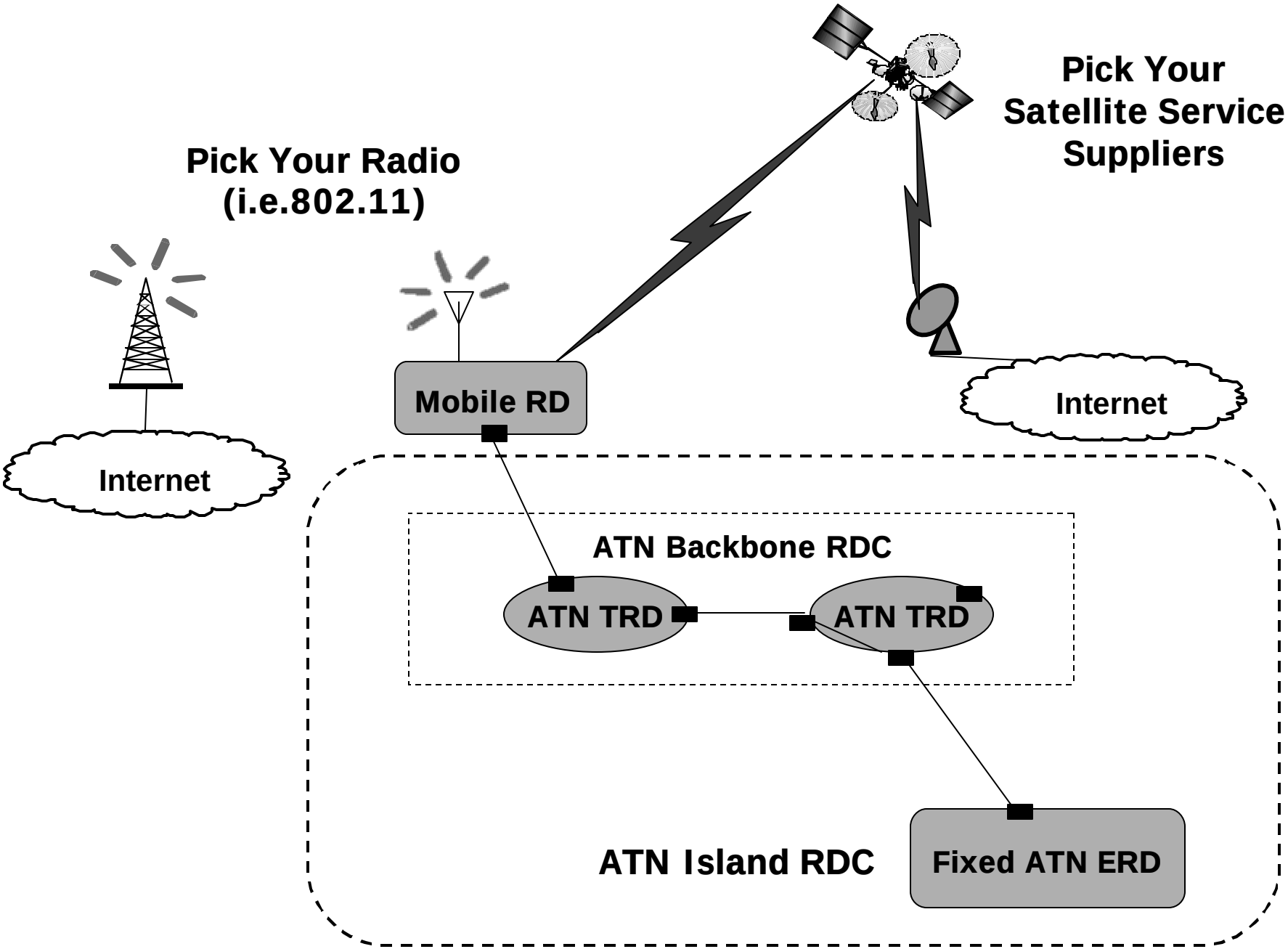
and pick

“Papers and Presentations”

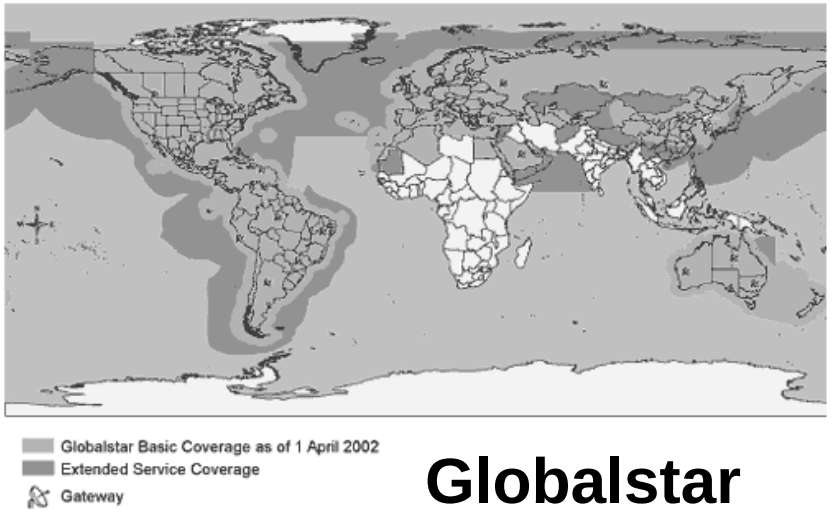
Backup

ATN Island Routing Domain Confederation Structure

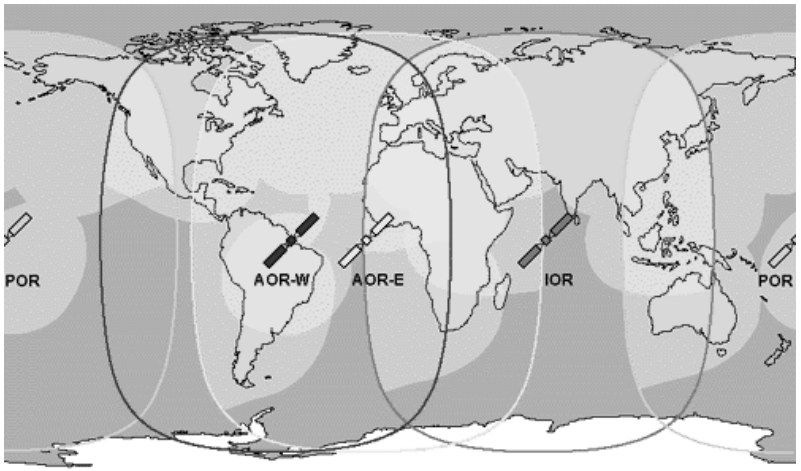



Pick Your Satellite Service Suppliers
Pick Your Radio (i.e.802.11)
Mobile RD
Internet
Internet
ATN Backbone RDC
ATN TRD
ATN TRD
ATN Island RDC
Fixed ATN ERD

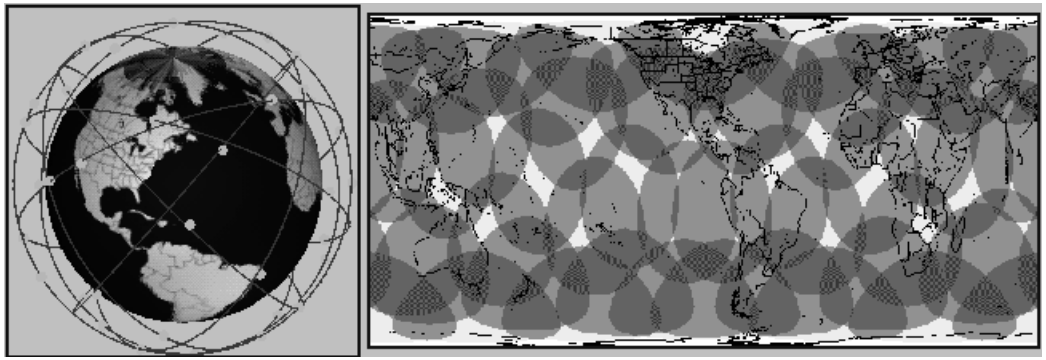
Satellite Coverage



Globalstar



INMARSAT

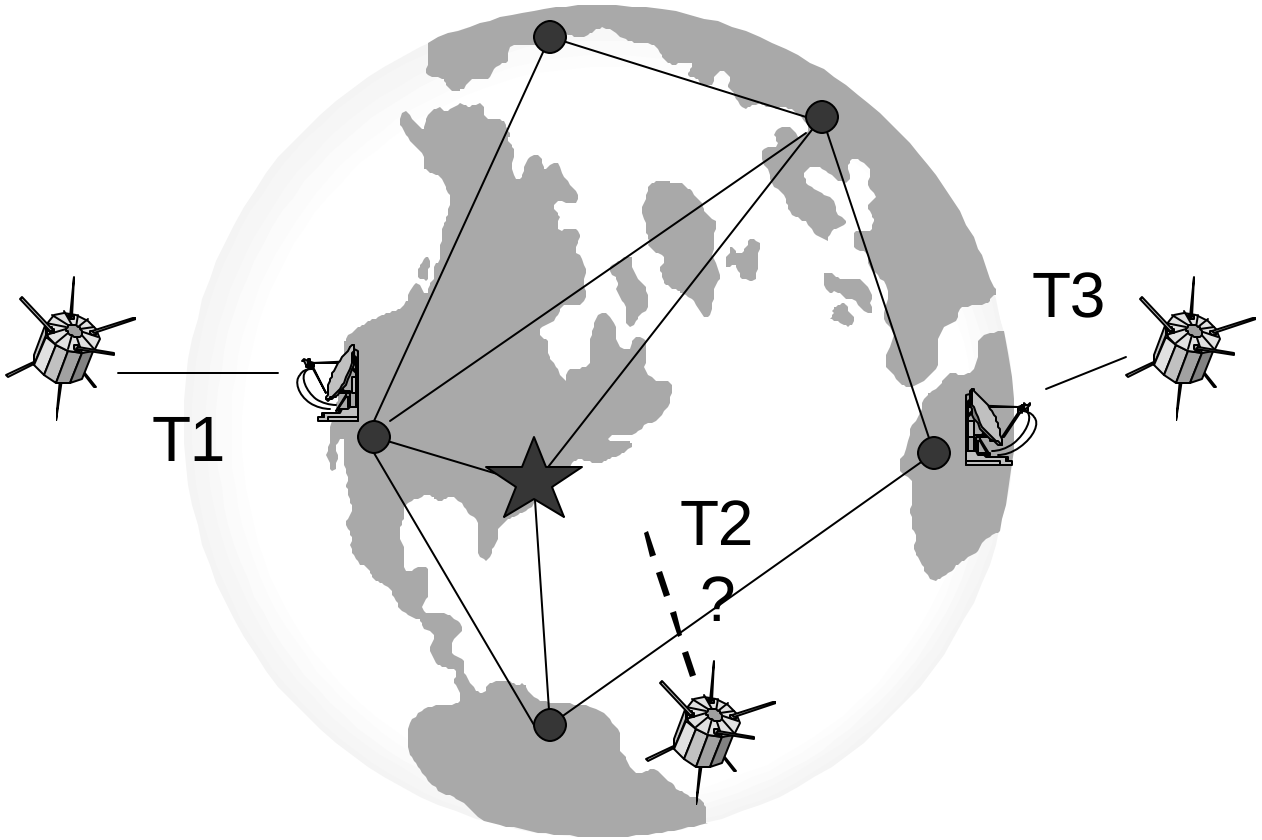


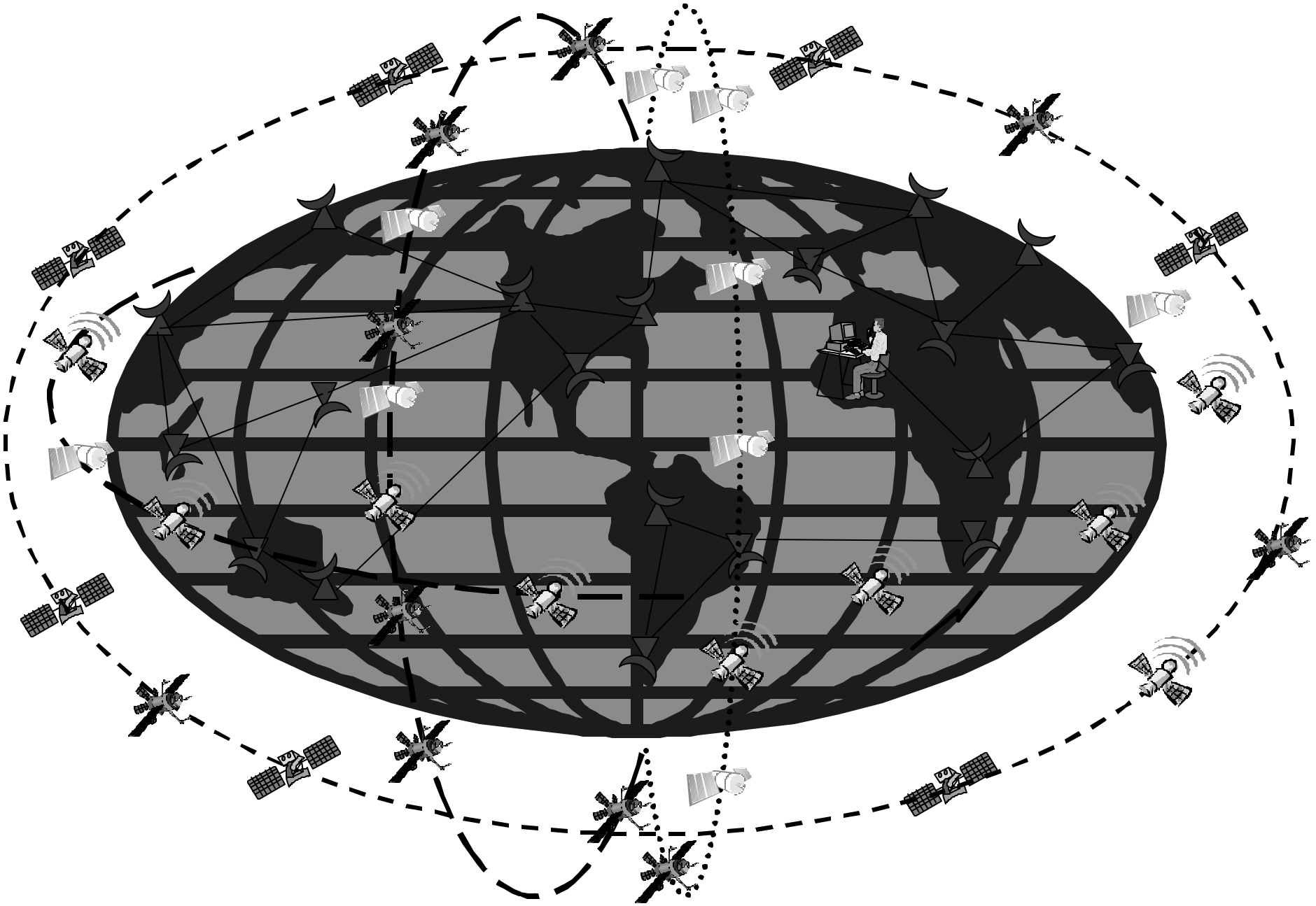
From SaVi

NASA’s Space-Based Needs

Mobile Networks

Earth Observation





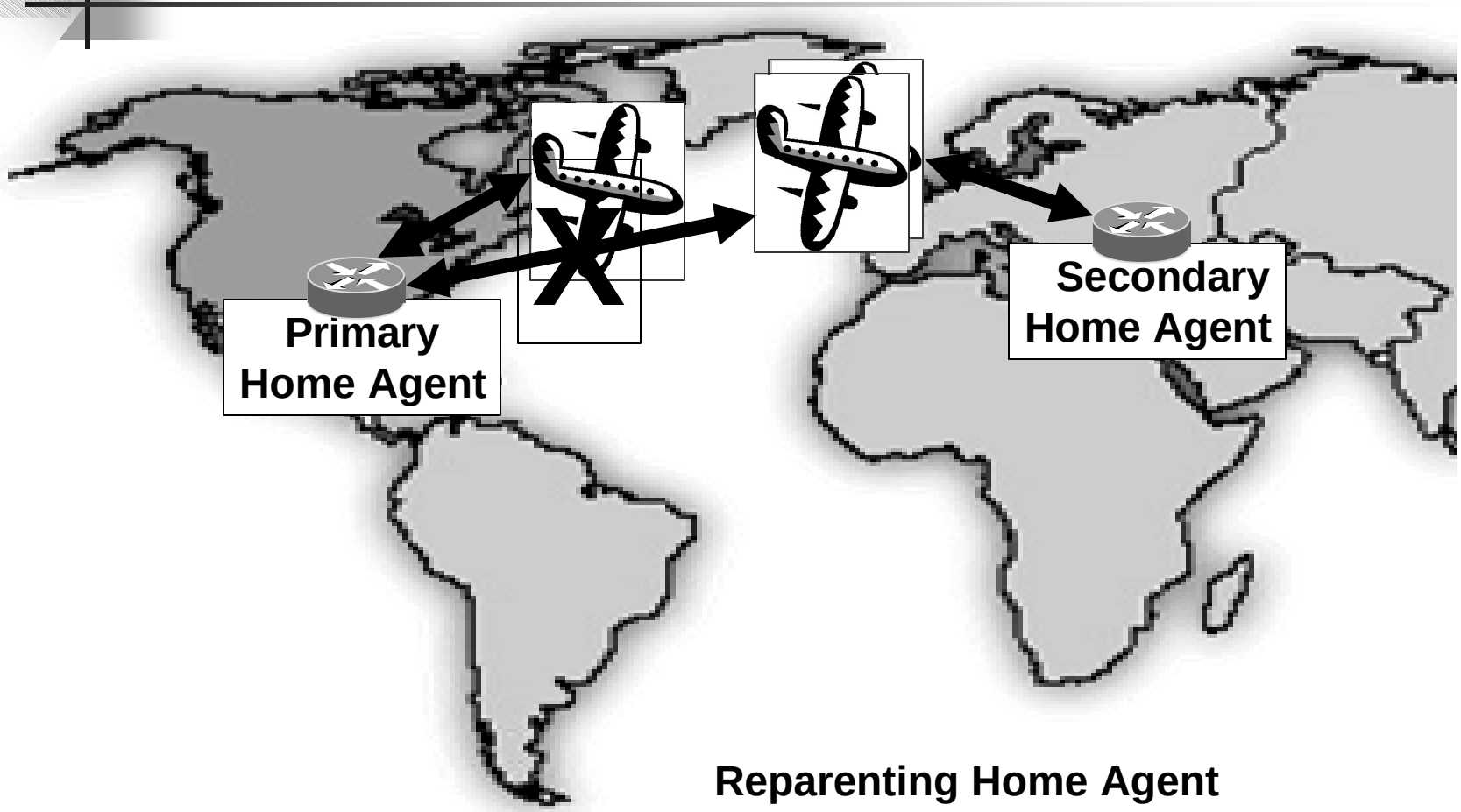
Space Flight Implementation

- Sharing Infrastructure
  - Common Media Access
  - Common Ground Terminal Capabilites
  - Common Network Access
    - AAA
  - Common Modulation and Coding
    - Software Radio

Mobile Networking
IPv4 Additional Features

- Geographically Distributed Home Agents
- Asymmetrical Pathing

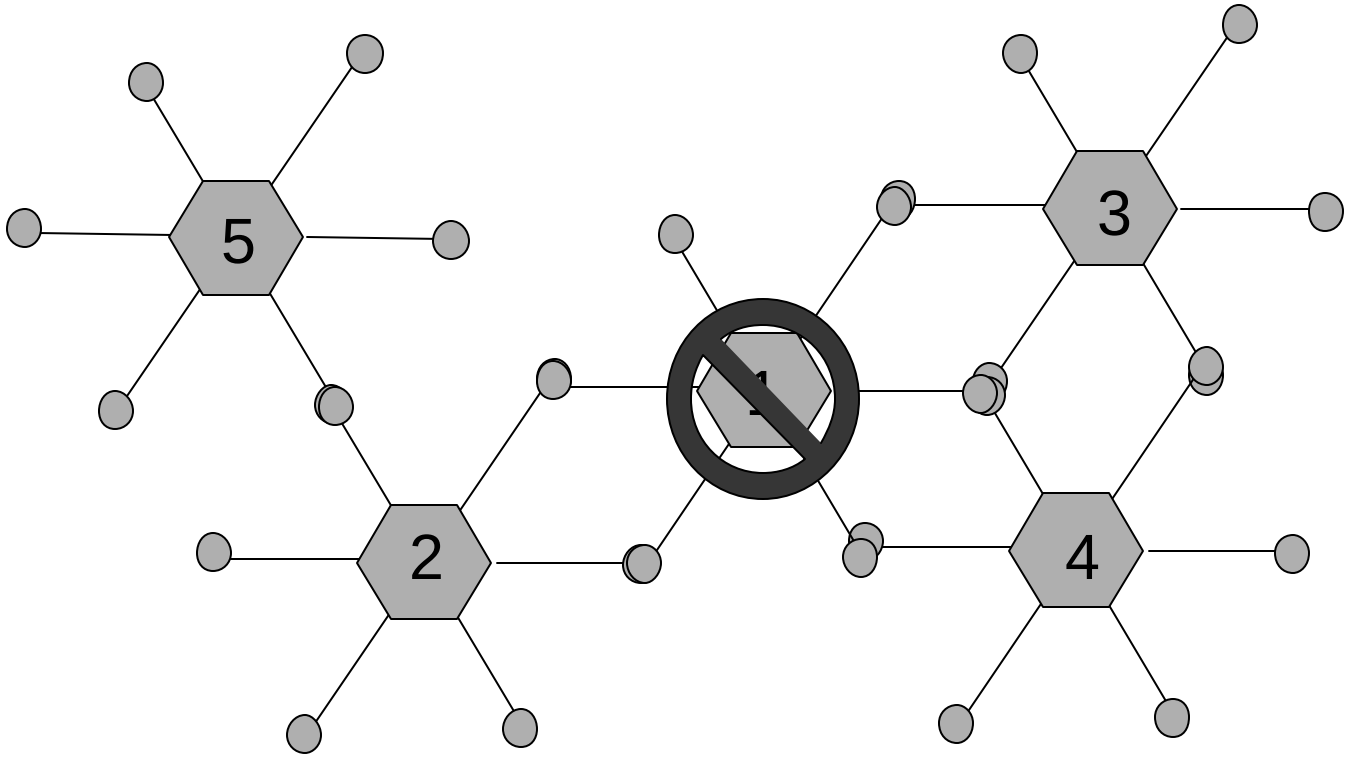
Geographically Distibuted Home Agent



Reparenting Home Agent
Helps resolve triangular routing
Problem over long distances

Secondary Home Agent (Fully Meshed Network)

If primary control site is physically incapacitated, a second or third or forth site take over automatically.



Asymmetrical Pathing